(E) Remarks

Formal drawings are submitted herewith in response to Draftspersons objections on Form PTO 948. Figures 1-2 and 4 have been designated with the legend "Prior Art" as required in the Office Action. If the attached formal drawings are satisfactory it is requested that they be forwarded to the Draftsperson. A second copy of the drawings are submitted herewith for the convenience of the Examiner.

The specification has been amended to correct the informality noted by the Examiner.

Claims 1-7, 13-20, and 24-24 were rejected under 35 U.S.C. 103(a) as being unpatentable over Partyka et al, U.S. Patent 6,131,071 issued October 10, 2000, and filed January 19, 1999, in view of Cox et al., "Maximum Entropy Analysis of Dispersed Seismic Signals", Geophysics, Vol. 51, No. 12, December 1986, pages 2225-2234.

It was stated in the Office Action that "Partyka et al. fail to disclose the transform having poles in the unit-z circle, where z is the z-transform. Nevertheless, Partyka et al, suggest that a wide variety of discrete data transformations other than the Fourier (column 38, lines 13-24) can be used to identify thin bed effects." And that "Cox et al, disclose "Maximum entropy power spectral analysis eliminates the resolution constraints imposed by convolution of window's Fourier transform with the spectrum of the trace segment" (Cox, page 2225, column 1, paragraph 3). In other words, using maximum entropy method will enhance the resolution of a moving window analyzer. Specifically, Cox et al. disclose the missing element that the transform having poles on the unit z-circle, where z is the z transform."

Claims 8-12 and 21-23 were rejected under 35 U.S.C. 103(a) as being unpatentable over the combined teachings of Partyka et al., U.S. Patent 6,131,071, issued October 10, 2000, and filed on January 19, 1999, and Cox et al., Maximum Entropy Analysis of Dispersed Seismic

Signals", Geophysics, Vol. 51, No. 12, December 1986, pages 2225-2234, and further in view of Kern et al., Patent 4,665,390 issued May 12, 1987.

In the Partyka et al. disclosure, it is said that the invention is motivated by the observation that the reflection from a thin bed has a distinctive expression in the frequency domain that is indication of the thickness of the bed. A homogeneous thin bed introduces a periodic sequence of notches into the amplitude spectrum of the composite reflection, said notches being spaced a distance apart that is inversely proportional to the temporal thickness of the thin bed. (col. 7, lines 14-21) It is further stated that the distance between the notches so introduced is equal to the inverse of the"temporal thickness" of the thin bed layer, temporal thickness being the length of time that it takes for a wavelet to traverse the layer in one direction. (col. 13, lines 15-18)

In the Partyka et al. method, a zone of interest is selected and a Fourier transform is used to produce a spectral decomposition of every seismic trace that intersects the zone of interest. Once the spectral decompositions have been calculated and stored, they are ready to be used in the geophysical exploration for thin beds. It is stated that the preferred method of viewing the transform coefficients is to begin by forming them into a 3-D "volume" (tuning cube), in which the vertical ("z") axis is no longer time as it was before the transformation but rather now represents, by conversion, units of frequency, as Fourier transform coefficients are stored therein. (see col. 7, line 55 through col. 8, lines 13)

In the tuning cube arrangement, a horizontal slice represents all of the coefficients corresponding to a single Fourier frequency and, thus is a constant frequency cross section. It is stated that the preferred way to locate and visualize thin bed effects is by viewing successive horizontal slices through the volume of coefficients. The animation preferably takes place on the computer monitor of a high speed workstation.

In another aspect the data are decomposed into a series of Fourier transform 2-D lines or 3-D volumes by using a series of overlapping short window Fourier transforms, rather than

applying a single window Fourier transform to each trace. As each short-window Fourier transform is calculated, the coefficients resulting therefrom are respectively stored within an individual tuning cube that remains associated with the short -window that gave rise to it. Each short window tuning cube produced by a sliding window may now be individually examined in exactly the same fashion as that proposed previously for the first embodiment. (See col. 8, line 63 through col. 9, line 41)

In another embodiment the data are decomposed into a series of Fourier transform 2-D lines or 3-D volumes by using a short window Fourier transform and are then reorganized into single frequency tuning cubes thereby providing enhanced imagery of thin bed layers. (See col. 9, lines 42-49)

The coefficients from each short window transform are accumulated. In the instant case, however, rather than viewing the calculated Fourier transform coefficients as tuning cubes, the data are reorganized into single frequency energy cubes, which can thereafter be examined either in a horizontal or vertical plane for evidence of thin bed effects. Each constant frequency cube may be viewed in plan or horizontal view, or in any other manner, thereby providing a means for visualizing geological changes with lateral extent for a particular frequency. (See col. 9, lines 53-63)

The rejection of claim of the claims, as amended, under 35 U.S.C 103(a) is respectfully traversed. With reference to claim 1, neither Partyka et al. nor Cox et al., either alone or in combination, disclose, teach or suggest:

> determining the frequency having the greatest amplitude within the frequency spectrum of the seismic data within said successively selected windows; and
>
> utilizing said determined frequencies having the greatest amplitude to generate a thin bed seismic display in which horizontal dimension represents distance and vertical dimension represents time.

It is noted in the Office Action in the rejection of claim 15 that Partyka does disclose locating the maximum frequency within a window. However, there is no teaching or suggestion in Partyka for using the maximum frequency or the amplitude at the maximum frequency in an investigation of thin beds.

Beginning on line 26 of column 25 of Partyka et al. and extending through line 10 of column 38, there is a discussion of "Alternate Tuning Cube Attribute Displays", which begins with the statements that "It is anticipated by the instant inventors that the tuning cube technology disclosed herein might yield additional insights into seismic reflection data beyond the detection and analysis of thin beds discussed previously.. . . In general, seismic attributes that have been formed into a tuning cube will be displayed and examined for empirical correlations with subsurface rock contents, rock properties, subsurface structure or layer stratigraphy. There then follows a discussion of "The Phase Spectra Tuning Cube", "The AVO Tuning Cube", "Angle Trace Tuning Cubes", "Multi-Trace Seismic Attributes", in addition to the discussion of "Frequency-Related Tuning Cube Attributes".

In a subsection of the disclosure in Partyka et al. that begins at column 31, line 17, there is a discussion of "Frequency-Related Tuning Cube Attributes", in which it is stated that "the instant inventors have found that a display of the peak frequencies calculated from a 4-D spectral decomposition provides still another display useful in exploration settings.(col 31, lines 19-22). It is further stated that "Those skilled in the art will recognize that the seismic attribute "location of maximum frequency" is just one of many that could be calculated from the values in a tuning cube." (Col. 31, lines 53-56). The disclosure then lists the following attributes that could be calculated:

- average spectral magnitude or phase,
- peak frequencies,
- location of maximum frequency,
- location of minimum frequency,
- amplitude at maximum frequency,

- amplitude at minimum frequency,
- average spectral amplitude,
- ratio between maximum and minimum frequency,
- ratio between the amplitude at the peak frequency and the amplitude at twice that frequency, and

Hilbert-transform related attributes such as

- the instantaneous phase,
- instantaneous amplitude,
- amplitude envelope,
- analytic signal, and
- change of spectral amplitude or phase with frequency.

Of all the attributes mentioned which it is said could be calculated, only the "change of spectral amplitude or phase with frequency" is mentioned as being useful in connection with an investigation of thin beds. There are no teachings or suggestions of applicant's invention, for example, as claimed in claim 1, of:

> determining the frequency having the greatest amplitude within the frequency spectrum of the seismic data within said successively selected windows; and
>
> utilizing said determined frequencies having the greatest amplitude to generate a thin bed seismic display in which horizontal dimension represents distance and vertical dimension represents time

Claims 2-14 and 24-25 are dependent directly or indirectly from claim 1 and should be allowable for at least the reasons advance above with respect to claim 1. Claim 2 claims the embodiment of the invention in which the seismic display generated according to the present invention represents the frequency having the greatest amplitude within each said frequency spectrum. Claim 5 claims the embodiment of the present invention in which the seismic display generated according to the present invention represents the amplitude of the frequency having the

greatest amplitude. Claims 8 and 10 claim the embodiment of the invention in which the frequency having the greatest amplitude is used to calculate the bed thickness and the seismic display generated according to the present invention represents bed thickness.

Claims 15, 18, 21 include substantially the same limitations as claim 1 and should be allowable for at least the same reasons advance above with respect to claim 1. Claim 15 includes:

> determining the frequency value of the frequency component having the greatest amplitude within each said frequency spectrum and
>
> utilizing said determined frequency values to generate a thin bed seismic display in which the horizontal dimension represents distance and vertical dimension represents time

Claim 18 includes:

> determining the greatest amplitude of the frequency components within each said frequency spectrum and
>
> utilizing said amplitudes to generate a thin bed seismic display in which the horizontal dimension represents distance and the vertical dimension represents time

Claim 21 includes:

> determining the frequency component having the greatest amplitude within each said frequency spectrum:
>
> calculating the kurtosis of each said frequency spectrum;
>
> determining if the kurtosis of each said frequency spectrum exceeds a selected value of kurtosis; and
>
> utilizing said frequency components having the greatest amplitude within said frequency spectra having a kurtosis value which exceeds said selected value of kurtosis to calculate bed thickness; and utilizing the calculated bed thickness to generate a thin bed display in which the horizontal dimension represents distance and the vertical dimension represents time

Dependent claims 16, 17, 19, 20, 22 and 23 are depended from independent claims 15, 18 and 21 and should be allowable therewith.

In view of the foregoing amendments and remarks, reconsideration and allowance of the pending claims is respectfully requested. The invention as defined in the claims is neither anticipated nor obvious in view of the cited referenced, either alone or in combination. A Notice of Allowance is respectfully requested.

Respectfully submitted,

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